Future Warming Impacts on Orographic Precipitation Extremes over Sierra Nevada: Linking Large-scale Forcing from CESM-LENS to Fine-scale Climate Features

HYPERION — Understanding Hydroclimate Data with Use-Inspired Metrics

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1 - Motivation and goals

Background: A majority of annual precipitation along the U.S. West Coast including California originates from a few intense atmospheric river (AR) events mainly impacting Sierra Nevada

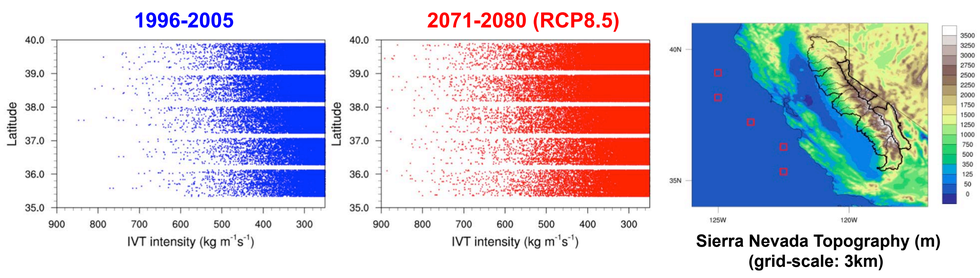
Understanding how ARs-driven precipitation extremes ARs may be influenced by climate change is of critical importance for future water resource and flood risk planning

Questions: **How future warming impacts precipitation extremes in the form of most heavy AR events over California's Sierra Nevada?**

What controls the geographical distribution of the precipitation changes during future extreme atmospheric river events?

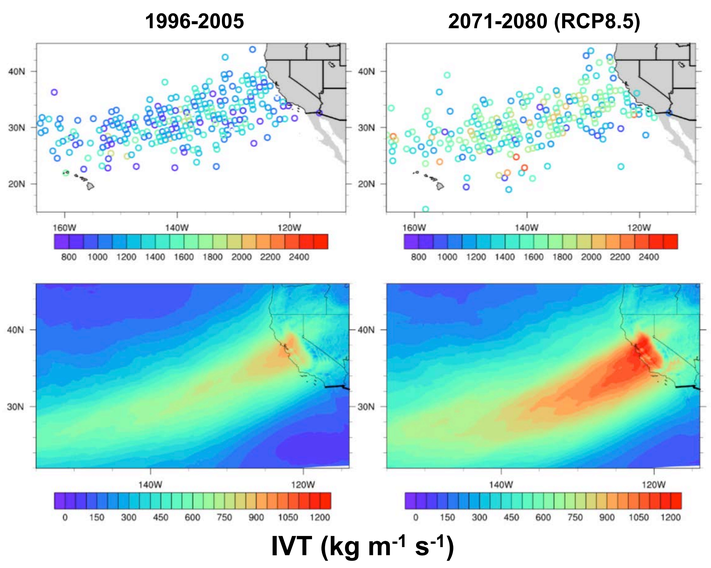
Methods and experiments: A selection of most extreme AR events from the historical period (1996-2005) and the future period (2071-2080) is studied under dynamical downscaling method using WRF forced by large-ensemble CESM output

2 - Moisture flux transport intensity



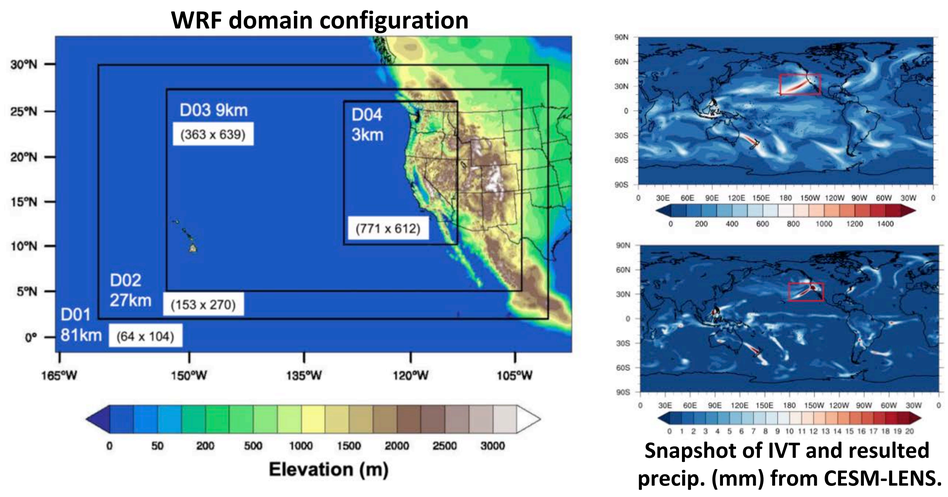
- Spatial distributions of the IVT (integrated water vapor transport) from CESM large ensembles (LENS)

3 - AR detection and selected events



- Grid trajectories of each selected top 40 AR events for historical and future periods
- Overall consistent dynamical pattern for the moisture flux transport between two periods
- The major hitting area of AR events is distributed over the central California, which in turn results heavy orographic precipitation over Sierra Nevada

4 - Dynamical downscaling (forced by CESM-LENS)

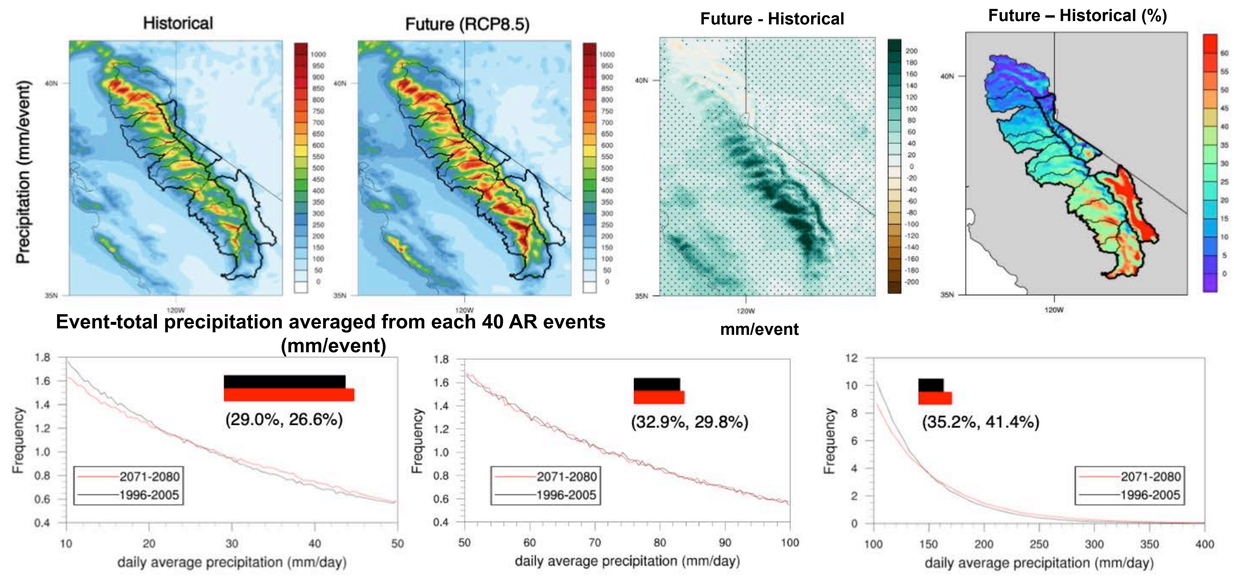


- Dynamically downscaled the large-scale forcing from CESM-LENS to finest as 3km over study regions for all of the 80 extreme AR events.

Reference

X. Huang*, A.D. Hall, and D.L. Swain, **Future Warming Impacts on Orographic Precipitation Extremes over Sierra Nevada: Linking Large-scale Forcing from CESM-LENS to Fine-scale Climate Features,** *to submit*

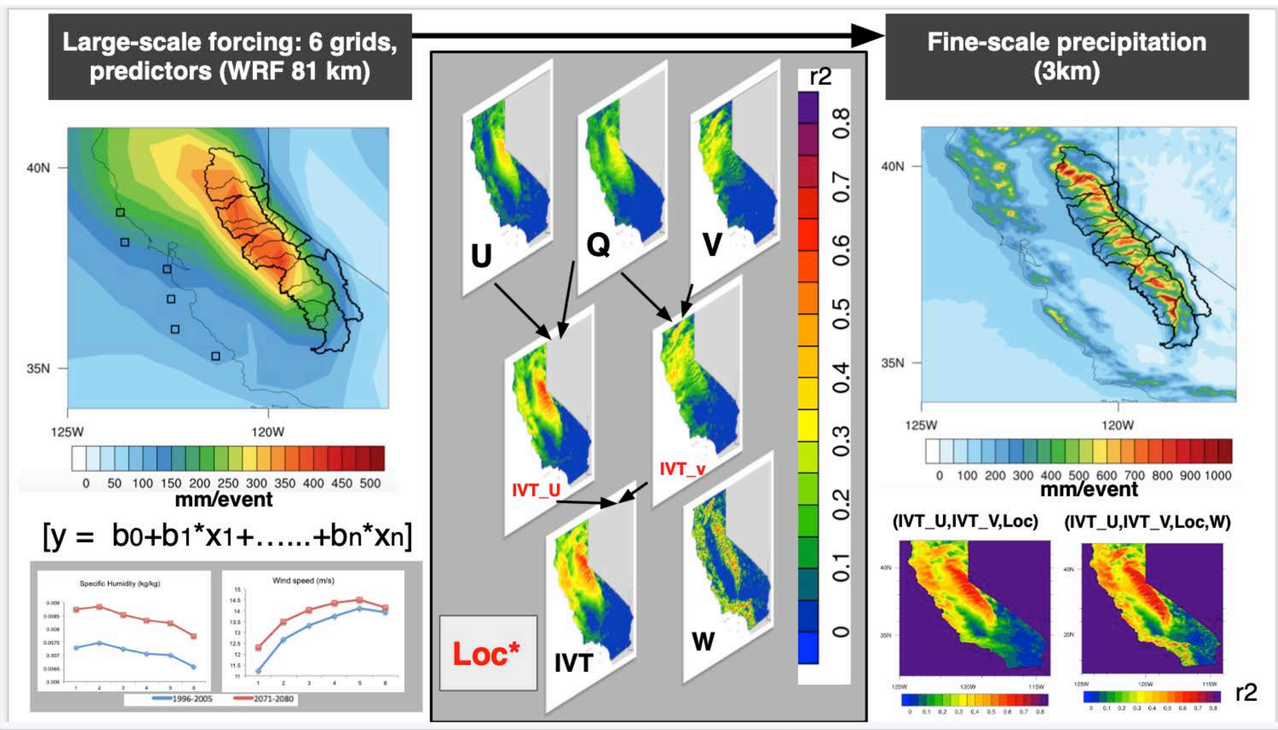
5 - Changes of precipitation extremes



PDF plot for the daily precipitation distribution under different intensity levels. Histogram for the daily precipitation frequency under certain intensity levels and proportion to total precipitation amount averaged over the Sierra Nevada

- **Intensified precipitation extremes** in the future with varied spatial details
- Future changes of precipitation **shows a shift of the precipitation intensification to the southern SN watersheds** reaching 50%. A notable **increase of the lee-side precipitation** (reaching more than 50%) with highly increased water vapor transporting to the downward side of the mountain ranges.
- Future AR extremes tend to **shift to upper tail of the precipitation intensity** with elevated flood risk

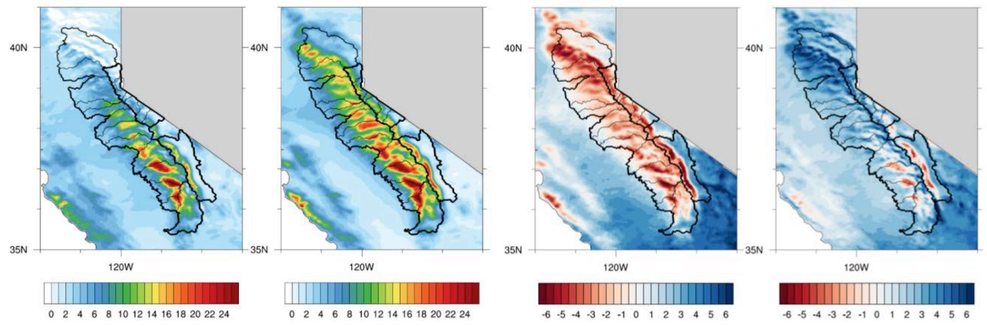
6 - Linking large-scale forcing to fine-scale precipitation features



Large-scale forcing | **Variance (r2) explained by the large-scale predictors (81km) for the fine-grid (3km) precipitation** | **Resulted best-fitting multi-regression model with simplicity**

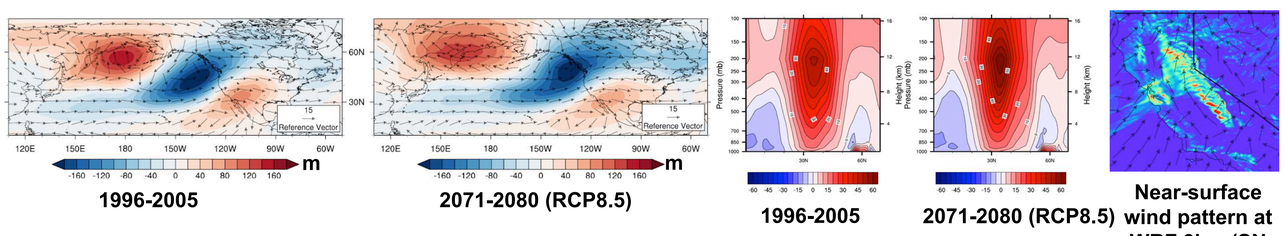
- Location factor refers to the area that the maximum IVT hits as the influx is the control of the AR-relevant rainfall
- **Thermo-dynamical factor is the main driver** for AR-related precipitation extremes and changes
- Local orographic forced vertical motions adds some value mainly at southwest coast given the control of the moisture flux

Simulated precipitation changes V.S. the linear regression model fitted precipitation change



- The fitting model (IVT_U,IVT_V,Loc) underestimates the historical precip., but overestimate the future values with resulting amplified changes.

7 - Large-scale meteorological patterns with local dynamics



Geopotential anomaly at 500hPa with wind circulation pattern for the simulated AR events from CESM-LENS

Averaged vertical profile of the zonal wind for maximum precip. days over each 40 events from CESM-LENS